



Efficiency Measurement on FWD/RWD/DRY DCT Transmissions

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. Determine the mechanical efficiency of FWD/RWD manual transmissions at various torque, speed and operating temperatures when engaged at different gear positions.

The efficiency of a manual transmission shall be measured on a test bench, driven by an electric motor.

1.2 Foreword. The mechanical efficiency of the transmission has a direct influence to the overall fuel consumption of a vehicle. The results from the measurements of mechanical efficiency are used in the simulation model to predict the vehicle fuel economy.

1.3 Applicability. For FWD, RWD manual transmissions and dry DCT.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.3 The test bench requires an input engine (electric motor), which can drive the corresponding nominal torque of the transmission and two FWD brake generators or one RWD brake generator, which can receive the translated torque (test set-up, see Appendix A).

3.2 Equipment. The upper range of the torque transducers should be as low as possible to keep the accuracy as high as possible. The examples below are relevant for transmissions of medium sized vehicles. Heavy duty transmissions require a higher upper range.

3.2.1 (One) 1 x Torque Transducer, input side (e.g. HBM T12, upper range = 500 Nm).

3.2.2 (Two) 2 x Torque Transducer, output side (e.g. HBM T12, upper range = 3000 Nm).

3.2.3 (Three) 3 x Speed Sensor with an accuracy ≤ 0.03 % (e.g. integrated in HBM T12).

3.2.4 (Three) 3 x Amplifier with an accuracy ≤ 0.005 % (e.g. HBM ML60B), in case an analog signal transmission is used. No Amplifier is used, if the signal transmission via CAN Bus is used (preferred version).

3.2.5 A Signal transmission via CAN signals should be used if possible, to eliminate the error of the amplifiers.

3.2.6 A Digital measurement system (e.g. IMC Cronos PL).

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3.3 Test Vehicle/Test Piece. Complete FWD or RWD manual transmission with clutch disk and axle shafts.

3.4 Test Time.

Calendar time: 8 days including run-in

Coordination hours: 4 h

3.5 Test Required Information.

- Oil fill quantity and oil type
- Gear ratios and final drive ratio to adjust the bench control system
- Maximum permitted torque for all gears
- Type of clutch system and instructions for assembly

3.6 Personnel/Skills.

Test bench operator: Knowledge is required about test bench control and torque transducers.

Development engineer: Knowledge is required about torque transducers, measurement equipment and accuracy.

4 Procedure

4.1 Preparation.

4.1.1 Gather all information required to perform the test (3.5).

4.1.2 Create a test protocol (see Appendix B). The test protocol defines, which operating points shall be measured. Do not measure higher torque, than the transmission.

4.1.3 Install the transmission on the test bench in its vehicle assembly position.

4.1.4 Fill in the oil type and volume specified for the transmission. If the transmission had been drained before, please watch the oil rest amount when filling oil to desired volume.

4.1.5 If the transmission is new, it is subject to a run-in program (see Appendix C).

4.1.6 Switch on the measurement system and amplifiers 30 minutes before the start of data acquisition. This warm up phase is required to allow a stable operating temperature of the measurement equipment. Use other warm up times, if recommended by the supplier of the measurement system supplier.

4.1.7 Perform Zeroing.

4.1.7.1 Operate the transmission with a medium load and speed until the torque transducers have reached a stable temperature (typically $+35 \pm 5$ °C depending on the test bench layout (use a temperature, which will typically show up during measurements, subject to experience).

4.1.7.2 Stop the operation of the transmission. Remove the shafts between the transmission and the torque transducers. The transducers are now at zero load.

4.1.7.3 Reset the torque measurement to zero.

4.1.7.4 The temperature during this “zeroing” shall be kept during the actual data acquisition with a tolerance of ± 5 °C.

4.1.7.5 Reconnect the shaft.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 As the principle of measurement is based on the elastic deformation in the torque transducer, all temperature fluctuations and distortions at the torque transducers shall be avoided. Keep the temperature during the data acquisition at the temperature at the “zeroing” with a tolerance of ± 5 °C.

4.2.2.2 Any shaft misalignments shall be corrected by suitable couplings.

4.2.2.3 During the whole measurement process, a constant oil sump temperature ± 2 °C is required. This can be achieved by “air cooling or heating” via a fan. Effects to the efficiency by heating or cooling shall be avoided (e.g. “don’t heat the bearings by fan”).

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4.3 Instructions.

4.3.1 Operate the transmission with a medium load and speed until the torque transducers have reached the operating temperature as recorded during zeroing.

4.3.2 Continue to operate the transmission with a medium load and speed, until the desired oil sump temperature is reached (typically +40 °C or +80 °C). To provide a proper lubrication of all parts of the transmission, all gears should be operated at 2000 min⁻¹ for at least 3 minutes during this warm up phase.

4.3.3 The operating points are defined in the test protocol (see Appendix B). Each operating point shall be adjusted and measured separately. There is no need for a particular sequence. Additional measurements are in the responsibility of the development engineer.

4.3.4 The measured data for each operating point are the average over 3 s with a sampling rate of 5 kHz. Slower sampling rates can be used if the sampling time is extended accordingly.

4.3.5 Recorded data include at least the torque, temperature and speed at each of the three torque transducers and the oil sump temperature.

5 Data

5.1 Calculations. The efficiency rate is the calculated ratio between output and input power. Due to defined gear ratios in manual transmissions the quotation efficiency rate needs only input and output torque. No speed measurement is required, which reduces the measurement errors.

$$\text{Efficiency (\%)} = \frac{\text{output torque left} + \text{output torque right}}{\text{input torque} \times \text{overall ratio}} \times 100 \% = \frac{M_{d_{\text{out left}}} + M_{d_{\text{out right}}}}{M_{d_{\text{in}}} \times i_{\text{ges}}}$$

$$\text{Torque Loss} = \text{input torque} - \frac{\text{output torque left} + \text{output torque right}}{\text{overall ratio}} = M_{d_{\text{in}}} - \frac{M_{d_{\text{out left}}} + M_{d_{\text{out right}}}}{i_{\text{ges}}}$$

$$\text{overall ratio } i_{\text{ges}} = \text{gear ratio} \times \text{final drive ratio} = i_{\text{gear}} \times i_{\text{FD}}$$

5.2 Interpretation of Results. The calculated mechanical efficiency will show the influence of the input torque and speed to the transmission mechanical efficiency and torque loss at each gear position at the specific lube oil operating temperature.

5.3 Test Documentation.

5.3.1 The measurement results should be evaluated graphically (see Appendix D) and in tabular form. The constant parameters gearbox, final drive, gear set, torque increment, temperature increment, oil type, oil volume and measurement number shall be recorded. The diagrams shall facilitate comparative statements concerning the reproducibility of results as well as a determination of interrelationships between individual parameters.

5.3.2 For the error assessment, a detailed error calculation shall be provided that includes all errors caused by the test bench (e.g. bearing losses), if not compensated, as well as the errors of the measuring chain.

For an example of the error assessment of the measuring chain, see Appendix E.

6 Safety

This Engineering Standard may involve safety requirements for hazardous materials, the method of operations and equipment. This standard does not propose to address all the safety issues associated with its use. It is the responsibility of the user of this standard to ensure compliance with all appropriate safety and health practices. This would include any specific training that may be required. The safety and health standards include site specific rules and procedures, company rules and procedures, and Government Standards. Contact shall be made with the appropriate site Safety and Health personnel for further direction and guidance in these matters.

7 Notes

7.1 Glossary. Not applicable.

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7.2 Acronyms, Abbreviations, and Symbols.

DCT	Double Clutch Transmission
FWD	Front Wheel Drive
MT	Manual Transmission
RWD	Rear Wheel Drive
SSTS	Sub System technical Specification

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW16916

9 Release and Revisions

This standard was originated in January 2013. It was first approved by MT System PMT in August 2015. It was first published in August 2015.

Issue	Publication Date	Description (Organization)
1	AUG 2015	Initial publication.

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